Second international conference on computational and cognitive musicology

Utrecht University, Netherlands, October 2024
Organised by the Music Information Computing Group
Peter van Kranenburg, Anja Volk, Mirjam Visscher, Frans Wiering

Wednesday 16 October, Minnaert Building, room 3.12

Leuvenlaan 4, 3584 CE Utrecht

Early Music Hack Day (satellite event) 9:30-17:30

Thursday 17 October, Botanic Gardens, Wachendorff room

Budapestlaan 17 3584 CD Utrecht

Registration 10:00-10:20

Music information computing for health and wellbeing 10:20-11:20

Chair: Frans Wiering

Anja Volk. ***Kick-off reflection on Music Information Computing at Utrecht University***
In this talk I will present a short overview on the different research topics of the Music Information Computing group at Utrecht University, many of which are related to topics presented at this conference, such as computational music analysis, early music computing, corpus studies of music, music for health and wellbeing, and automatic music generation. I will reflect on the importance of showcasing why and how our research at the intersection of computer science, musicology and cognition matters, both to colleagues outside our field and society. For instance, what does it take to establish research on music at a computer science department, or computational research in a musicology department? With this talk I intend to kick off a reflection during the two days of the conference on how to complement each other through interdisciplinary collaboration and demonstrate that music matters, and on how to strengthen our research field in the future.

Florence Levé, Sahar Moghimi and the PreMusic team. ***Designing musical and rhythmic stimuli for NICU interventions***
Perception of time intervals and rhythmic structures is critical for understanding the auditory world. Disturbances in these processes negatively impact language and musical development and, in turn, communication and social interactions (Ladanyi et al 2020). The third trimester of gestation is a critical period during which sound input affects how neural circuits develop along the auditory pathway. Therefore, premature birth and as a result, early exposure to the extra-uterine sound environment and deprivation of normal maternal/environmental sounds and rhythmic paUerns can have long-lasting effects on the cognitive development of children born prematurely.

The PreMusic* project aims at studying the impact of musical interventions, specifically targeting rhythm, on preterm infants in the Neonatal Intensive Care Unit (NICU) of the hospital, on auditory rhythm processing in their early development, from 28 weeks gestational age (wGA), 2 months before the equivalent age of

normal birth, to 18 months (corrected age a\er birth). The first step is thus to design musical interventions allowing to improve rhythm processing capabilities of the preterm neonates while taking care of their well-being.

This presentation proposes to describe the creation process of the musical stimuli, from the discussion with the consortium on the intervention protocol, the characteristics of the musical stimuli and their presentation, to the effective musical interventions in the NICU. I will discuss the benefits and limitations of using computational music analysis and generation approaches for such a sensible application.

References

Ladányi, E., Persici, V., Fiveash, A., Tillmann, B., & Gordon, R. L. (2020). Is atypical rhythm a risk factor for developmental speech and language disorders?. *Wiley Interdisciplinary Reviews: Cognitive Science*, 11(5), e1528.

* The PreMusic project is funded by the French ANR (Research NaRonal Agency)

Bastian Vobig. ***From Assessment Profile to Process Assessment: Challenges in Automating Music Therapy Analysis***

Improvisation in music therapy has been shown to be an effective technique for engaging clients in emotionally rooted (inter)action to treat affective mental disorders such as depression (Aalbers et al., 2017; Erkkilä et al., 2011). During improvisation, however, a variety of musical information is exchanged, resulting in a highly complex musical and interpersonal situation. While traditional models of music therapy analysis emphasise aural analysis and assessment of single sessions (Bruscia, 1987), more recent and elaborated methods, such as microanalysis, focus on the detailed development of improvisation sessions (Wosch, 2021; Wosch & Erkkilä, 2016), which comes at the cost of a more time-consuming application process. Digital processing, as in music information retrieval and machine learning, seems promising to accelerate the analysis process, but require considerable preliminary work in data preprocessing and formalising the high-level concepts used in music therapy to develop a suitable dataset.

The HIGH-M project (https://ifas.thws.de/en/high-m/) aims to combine the qualitative validity of microanalytic methods with the speed of digital processing, and therefore operates in a highly interdisciplinary research environment. In recent months, a computational approach for analysing music therapy improvisations and developing a dataset has been developed by combining models of social interaction (*Social Systems Game Theory*) (Burns et al., 2018) with microanalytic methods (*Improvisation Assessment Profiles - Autonomy Microanalysis*) (Wosch, 2007) and a data-based analysis- and music information retrieval tool (*Music Therapy Toolbox*) (Erkkilä & Wosch, 2018). Currently, this approach is being transformed into an automated analysis tool, consisting of a combination of rule-based programming and training of a supervised machine learning classification model, for further use in music therapy and research. The submitted presentation aims to provide insights into the challenges faced by the HIGH-M project in integrating a highly complex music therapy analysis model into a computational framework.

Coffee break 11:20-11:45

Computational ethnomusicology 11:45-12:45

Chair: Mirjam Visscher

Anna Aljanaki, Inna Lisniak. ***Comparing Estonian and Finnish Folk Dance Tunes for Violin Using Computational Methods***

Dance melodies are an important part of the traditional music of many peoples around the world. The most widespread and favorite instrument for accompanying folk dances in many nations is the violin. It is an

instrument that has extraordinary possibilities and is used in a variety of ways in both folk and academic music. The attention of the proposed study is focused on the corpora of violin dance music of the Nordic peoples – Estonians and Finns. As is well known, these peoples have many common features in language, culture, and traditions, due to their common historical past. At the same time, there are local differences in the musical language, particularly in violin dance music.

In this study, we have combined the knowledge of ethnomusicological research with computer analysis in order to better understand the internal structure of instrumental compositions and compare them. The rhythmic and metrical features of dance music depend on the genre of dance (e.g., polka, waltz).

Our research is based on two corpora: The Estonian and Finnish melodies for violin. The Estonian corpora includes 77 dance tunes (https://www.folk.ee/) and the Finnish corpus (702 tunes). We found that simpler meters dominated both corpuses, with polka being the most popular dance. There were differences as to how double and triple meters were distributed, and very few meters other than double or triple meter, as compared to other folk material, probably to them being not danceable enough. We found differences also in harmonic composition of the songs, with Estonian dances probably being used for festivities and weddings more so than Finnish ones. Melodic ranges were very similar in both corpuses, a little over an octave. Overall, although there were some differences between these corpuses, it is hard to classify a Finnish folk dance from an Estonian one using computational methods.

Ardavan Khalij, Nicholas Harley, Geraint Wiggins. ***Knowledge and Data Representation for Study of Traditional Iranian Music***

This paper applies knowledge representation and statistical modelling within the domain of Iranian traditional (early) music. Iranian music theory consists of a common repertoire (radif) of melodic fragments (gushes) organised into modes (dastgahs). The structural organisation of the theory diverges subtly from concepts familiar in Western music theory, and so presents a significant challenge from the perspective of knowledge representation, which has, to date, largely focussed on the Western tradition. A hierarchical knowledge base representing the traditional Iranian repertoire (radif) was constructed using the Common Hierarchical Abstract Representation of Music (CHARM) framework. The data underpinning the knowledge base consisted of Midi encodings produced by Dr Shafiei as part of her dissertation at City University of New York. Statistical modelling of the corpus was performed using the IDyOMS framework, a re- implementation and slight generalisation of the Information Dynamics of Music (IDyOM), which operates over CHARM knowledge structures. Three studies were performed on the knowledge base: the first used statistical models to predict which musical features of gushes are most important in characterising the radif; the second two used contrasting statistical methods to estimate the similarity between dastgahs. The results of these studies each reflect commonly agreed knowledge from Iranian musicology, and together constitute empirical evidence for a cognitive explanation of Iranian music practice, as well as a general validation of the methodology. Both the representational and statistical modelling frameworks used required extension to facilitate their application to Iranian music. These extensions are are publicly available, and constitute an additional contribution of the work.

Dániel Péter Biró, Peter van Kranenburg. ***A Computational Analysis of the Functionality of Melodic Contour in Qur'an Recitation***

In this study, we are developing a method of computational melodic contour analysis within Qur'an recitation, using examples of renowned reciters from an online dataset. While scholars have analyzed melodic profile, scale (*maqāmat)* and the use of elongation (*madd*) in Qur'an recitation (al Faruqi, 1987, Nelson, 1985) the functionality of melodic contour in Qur'an recitation has little mention in scholarly literature. Employing a dataset consisting of Egyptian, Saudi and Yemeni reciters, we have analyzed scale tones and their melodic contours within examples of the Qur'an Sura *Al-Qadr* (Sura number 97). Each recording has been converted to a sequence of frequency values using the YIN pitch extraction algorithm (De Cheveigne & Kawahara, 2002) by estimating the fundamental frequency within recited each word. In aligning

the words within the phrases (*ayat*) and employing density-estimation to determine the scale tones per word, it is possible to examine the levels of pitch hierarchy in the resulting scales as well as to determine a general contour of the melody in each word of each reciter. In comparing these examples from various recitation traditions, we are able to determine various contour patterns and similarities among the various reciations and reciters, allowing us to observe correlations between regional traditions and general tendencies in terms of the employment of melodic contour in both *murattal (plain)* and *mujawwad (elaborated)* versions of Qur'an recitation. Following this analysis, we are able to compare how the functionality of melodic contour relates to the use of eleongation (*madd*) and the rules regulating the correct oral rendition (*Tajwīd)* within Qur'an recitation.

Walking lunch 12:45-14:00

Early music computing (1) 14:00-15:00

Chair: Marnix van Berchum

Olja Janjuš. ***Case studies on computational analysis of German lute tablature***

With the development of computational tools for music analysis starting as early as the 1960s, and taking flight during the past two decades within the field of music information retrieval (MIR), we now have at our disposal a large number of tools, rule-based or machine-learned, which take as input symbolic representations, audio signals, or a combination of both. Moreover, early music and music not written in common Western music notation, like lute tablature, have also become a focus of digital and computational musicology in recent years.

These developments present us with the opportunity to take new approaches to corpora that have been temporarily put aside, either because of their obscure notation or because of lack of information about their performance, and that are almost impossible to read or interpret even for specialists. Lute tablature, for example, could be considered such a corpus, even though some research applying computational methods has already made an impact on our understanding of this corpus, resulting in tools and datasets that are crucial for further research. However, research into music written in lute tablature – especially German (lute) tablature – is still largely overshadowed by other research, not only in the field of MIR, but also in that of musicology.

This paper will combine current computer-based approaches with traditional, manual ones, applying different tools and encoding strategies. By using tools from *AbsoLutely Tabulous*, a toolbox for processing and analysing music in lute tablature, and directing the output into additional tools for music analysis, this research will focus on 1) the relationship between voicing and lyrics in vocal sources and lute arrangements thereof, 2) the 'type' of intabulation and 3) additional extended cadences or other figurations. The main material will be drawn from the manuscripts D-Mbs Mus. ms. 1512 and D-B Mus. ms. 40632 in combination with the larger corpora.

Ilias Kyriazis. ***Multimodality, annotations, and semantic interlinking in the E-LAUTE critical edition***

Critical editions take a crucial position in music literature and research. In contrast to printed formats, which are based on the subjective view and individual reading process of the editor, digital ones have established the idea of 'HyperEditing', a concept introduced in literary studies (McGann, 1995) that represents a multi-dimensional model for critical editions. The digital edition is intended as a 'fully networked hypermedia archive', which consists of 'virtual copies of the sources, connections between these, annotations with critical and contextual information, and analytical tools for searching and comparing the materials' (Wiering, 2009, p. 25).

The proposed presentation will showcase the multi-dimensionality of E-LAUTE (Electronic Linked Annotated Unified Tablature Edition), a multi-institutional research project establishing an open-access and interactive digital edition of lute tablatures of the German-speaking area 1450–1550. Although part of these tablatures has been well-known and widely performed, a great amount remains inaccessible to scholars, musicians, and the general public not only due to its complex notation (German lute tablature), but also because sources are scattered throughout Central Europe. E-LAUTE is sustainably digitizing this important part of European cultural heritage as machine-readable music encodings, unlocked for a contemporary audience through transliteration into currently understood (Italian and French) lute tablatures, transcription into common Western music notation, and merging with literary and instructional texts.

Alongside the music encodings, the edition will incorporate facsimiles, text encodings, performance recordings, and music annotations, all handled as Web resources and brought together into the final, digital editions platform at the Austrian National Library. In addition to an overview of the general infrastructure, the presentation will shed light on the use of ontologies and Linked Data vocabularies for interconnecting the aforementioned components, and it will also address the use of the music annotation model (Lewis et al., 2022) for incorporating performance-based and musicological contributions from external users and specialists, who will still be retaining full control over their data via decentralized Personal Online Datastores (Mansour et al., 2016).

Cited works

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Christophe Guillotel-Nothmann, Thomas Bottini, Philippe Cathé, Anne-Emmanuelle Ceulemans, Achille Davy-Rigaux, Marco Gurrieri, Félix Poullet-Pagès. *Tonalities, an application for the collaborative online analytical exploration of digital scores: a demonstration based on secular polyphonic works by Guillaume Dufay*

Tonalities is an application for the collaborative online exploration of digital scores. The software, developed at the IReMus as part of the H2020 Polifonia project, leverages semantic web technologies to produce theoretical models whose concepts can be associated with arbitrary musical selections via a highly ergonomic interface. The epistemological challenge taken up by Tonalities is to highlight different musical properties by comparing analytical viewpoints and keeping track of the reasoning that led to the production of documented and signed musical analyses (see Bottini *et al.* 2022 and Filaber *et al.* 2023).

Tonalities departs from previous initiatives: it does not approach music annotation from the perspective of their graphical representation (Eanalysis, iAnalyse, Dezrann) or of the encoding of their hierarchies (MuseReduce). Tonalities does not either focus on linking musical representations with contextual or interpretative knowledge (MEld). In contrast, our starting point is the formal definition of analytical concepts. This shift of perspective is central because it focuses on conceptualisation and on the strategies adopted to produce, explore, and share knowledge effectively at the level of as large a community of users as possible.

Based on a case study of secular polyphonic works by Guillaume Dufay, this paper will present the analytical features available and their contribution to musicology. We will illustrate the association of concepts with hierarchical musical selections by means of a systematic analysis of cadences. This analysis will highlight the heuristic contribution of the collaborative methodology through a presentation of the tools for comparing and commenting on annotations. The devices for systematically exploring the annotations will highlight some hitherto non-theorised aspects of the cadence structures identified, especially relating to open endings. To stimulate the ensuing discussion, our presentation will outline future development projects: completing the man-machine interaction cycle by proposing automated concept identification; coordinating symbolic score data with acoustic recordings; developing the iconic, symbolic, and diagrammatic representation of the interface.

References

Thomas Bottini, Christophe Guillotel-Nothmann, Nicolas Meeùs. Vecteurs harmoniques : le point sur la question. *Journée d'Analyse Musicale 2022 : L'analyse de l'harmonie aujourd'hui*, Dec 2022, Paris, France. ⟨hal-03923747⟩

Thomas Bottini, Christophe Guillotel-Nothmann, Marco Gurrieri, Félix Poullet-Pagès. Tonalities: a Collaborative Annotation Interface for Music Analysis. *Musical Heritage Knowledge Graphs workshop during the 22nd International Semantic Web Conference 2022*, Oct 2022, Hangzhou, China. ⟨hal-03923731⟩

Adam Filaber, Christophe Guillotel-Nothmann, Marco Gurrieri. Tonalities: Musical systems and their histories revisited through modeling and collaborative score annotation: A case study on "directed progressions" in secular works by Josquin and his contemporaries. *Global Digital Music Studies Conference*, CUNY Graduate Center; The Brook Center; RILM, Apr 2023, New York, United States. ⟨hal-04071815⟩

Break; walk to Koningsberger 15:00-15:30

Thursday 17 October, Koningsberger Building, ground floor

Budapestlaan 4a-b, 3584 CD Utrecht

Poster session (part 1) 15:30-16:15

Jens Johannsmeier, Kenneth Allan, Sebastian Stober. ***Improved Instrumental Retrieval for Riddim Albums***

Musical source separation is concerned with splitting a musical piece into different constituent tracks, such as singing and instrumental. Current approaches mainly use powerful deep neural networks and can be applied to a wide range of musical genres. However, these methods can result in audible artifacts or incomplete separation, limiting their usefulness, in particular for genres of music that are underrepresented in the training data. We present a method that can improve results of such systems specifically for so-called riddim albums from Jamaican reggae.

Here, several artists perform different songs on the same instrumental backing. We make use of this property, combining the results of off-the-shelf source separation methods like Demucs or Spleeter for a whole album, to achieve superior instrumental retrieval compared to the separated instrumental of single pieces. We show this improvement using quantitative metrics as well as a qualitative user study. Instrumental retrieval is of particular interest in reggae music, since this can restore previously lost riddims from complete pieces, allowing other artists to perform on them.

Furthermore, this can be seen as one instance of a general principle: That even powerful, generalist approaches for source separation can benefit from domain-specific considerations to achieve higher-quality results.

Nicholas Cornia. *Flemish Archive for Annotated Music (FAAM)*

The performance of a musical work is a complex ecosystem, where performance practice, academic research and audience reception interact together. The critical analysis of sources related to a musical work is often a time-consuming and cumbersome task. Critical editions of music scores primarily focus on the composer's agency, neglecting the contribution of a intricate network of agents, ranging from editors, conductors, amateur and professional performers.

The quest of reconciling scholarship and interpretative freedom has always been present in the early music movement discourse, since its 19th century foundations. Confronted with a plurality of performance practices, the performer of Early Music is forced to make interpretative choices, based on musicological research of the sources and their personal taste.

We wish to present the state of the Flemish Archive for Annotated Music (FAAM), an interdisciplinary project mapping the rich performance practice of musicians from 1800-1950 through the traces left by their marks on the score. Annotations are a valuable source of information to recollect the decision-making process of musicians of the past, especially when original musical recordings are not available. This digital corpus, including around 20.000 images with detailed metadata and a dedicated training set for image segmentation, presents unique challenges, opportunities and finds several applications in the fields of Computer Vision, Optical Music Recognition, Computational Musicology and Artistic Research.

The project wishes to create a digital platform for artistic researchers and musicologists, providing exploratory tools for understanding the plurality of interpretation of musicians from the long 19th century.

Website (under-construction) and GitHub repository:

- https://github.com/nicholascornia89/FAAM-dataset
- https://faam.laboxix-xx.be/viewer

Geert Maessen. *Expanded Dreams on Early Chant and Computation*

In his paper for MedRen 2024, Charles Atkinson envisioned three large-scale projects involving computational resources that would be of great benefit to chant scholars: 1. Virtual reconstruction of liturgical manuscripts from a myriad of fragments; 2. Developing tools to compare Western and Eastern chant; and 3. Creating a universal index of music-theoretical diagrams in all notated traditions. In this paper I will extend his dream to three even more ambitious areas:

1. The entire melos of the Mozarabic rite before 1000 has been preserved in musical notation. This notation, however, does not provide enough information to notate or sing its melos. Yet we know it must have been related to other traditions. It must be possible to develop tools for the computational generation of such melos. These generations in turn could be helpful for the comparison and understanding of other traditions. Something similar applies to Armenian, Georgian and other early chant traditions.
2. The central questions in Gregorian chant is the relationship between Gregorian and Old Roman chant. Which was first? Since we know there were several preserved traditions with mutual influence, there seem to be good reasons to approach this question computationally. Work on the realization of a computational mapping of relationsships between Gregorian, Old Roman, Ambrosian, Beneventan and other traditions could be of great benefit to chant scholars.
3. Ethnomusicology and paleography learn that tonality varied over time and place, especially concerning the size of the semitone. In the West this size roughly decreased from the ninth century onwards and from southern towards northern Europe. Much of this development is preserved in

music notation. For a better understanding of early chant, it would be useful to model these developments computationally, which in turn could benefit the two areas above.

Ugo Bindini. ***Introducing ReDiX: a digital tool for harmonic analysis in Renaissance polyphony***

In recent years, a lot of effort has been spent in developing music analysis softwares, which are able to interpret/analyze a big amount of data and to extrapolate relevant features; examples include Music21, the humdrum library, the CRIMproject. This has been accompanied by a constantly growing amount of music available in machine readable formats.

In order to use the most powerful softwares, however, a high degree of affinity with informatics and programming is required. As I explored this panorama, I felt the need for a tool which does not require any previous programming knowledge, but is still able to carry out a quick analysis of large data.
In this presentation, I will introduce my newly programmed software, ReDiX – Renaissance Digital eXplorer. The main goal of my software is harmonic analysis of Renaissance polyphonic music, taking a basso-continuo-like ciphering perspective. As corpus, this tool draws on the available (and growing) databases of the Josquin Research Project, the 1520s Project, the digitalization of Palestrina's masses. ReDiX allows to search after specific chord-signatures, and subsets thereof, and to show the score of the corresponding passages in the corpus; it also allows for statistical analysis, by showing the distribution of different chord-signatures, tailored on the specific question posed by the user.

As some selected examples and insights will show, such a tool sharpens the understanding of the music at hand, providing at times statistical confirmation of our hypotheses, at time surprising answers to our questions, and opening many fronts of discussion.

Viktor Lazarov. ***Quantitative Analysis of Baroque Performance Styles in the Keyboard Works of J. S. Bach and C. Graupner***

The interpretation of the keyboard works from the late German Baroque period served as the basis for two experimental studies. Two expert pianists recorded an excerpt of J. S. Bach's *Partita in C minor* BWV 826 and C. Graupner's *Passepied* GWV 325 in three historical (romantic, modern, and rhetorical) and two individual styles.

Quantitative analysis was conducted using MIDI data recorded on a Yamaha Disklavier DC7X grand piano and audio files recorded by two cardioid microphones. Analyzed parameters include key depression velocity, tempo variation, and overlap between notes for the Bach (study 1), and tempo, articulation, ornamentation, pedalling, dynamics, phrasing, and expression for the Graupner performances (study 2).

To extract parameters for the first study, the MIDI data stream encoding the performances was compared to a reduction of the original Bach score, edited in MuseScore, in which only the notes falling on the subdivisions of the measure (eighth notes) were preserved. Provided by the Matlab MIDIMatcher toolbox, *Dynamic score matcher* was used to match the MIDI-encoded performances performed by the pianist with its corresponding notation (MIDI score). A statistical analysis of key velocity, inter-onset intervals, and note overlap was performed on selected data.

For the second study, tempo variation from 15 takes (three takes per performance style) of Graupner's *Passepied* was measured by notating beats in Sonic Visualizer, while articulation, dynamics, expression, ornaments, timing, duration, and pedal use were notated on separate digital scores for each take. Using a plugin created by a MuseScore administrator, the number of occurrences of each parameter was counted automatically, providing accurate values for each style.

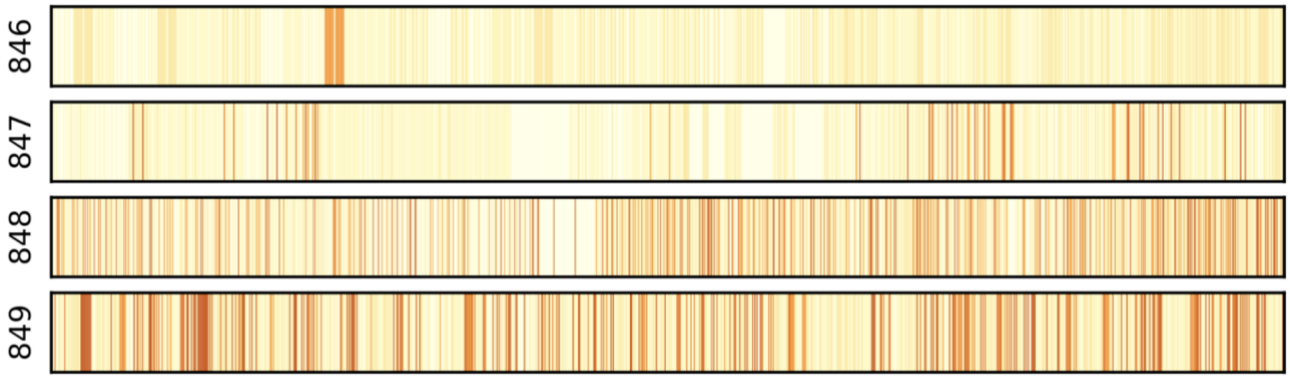
By discussing statistical results of performance parameters using histograms, graphs, diagrams, box plots, and stacked bars, historic performance styles are compared in terms of the relative proximity of their

parameters, while individual styles are defined as hybrids situated between the mean data of romantic, modern, and rhetorical styles.

Peter van Kranenburg. ***In search of Das Wohltemperirte Clavier***

Johann Sebastian Bach composed two sets of preludes and fugues in all major and minor keys under the title *Das Wohltemperirte Clavier*. Since there are twelve keys per octave on the keyboard, the total number of compositions per set is 24. For performing the cycles in their entirety, a keyboard temperament is required that allows all twelve keys to function as the tonic. The exact temperament Bach used is unknown. This has led to widespread speculation and numerous proposals for the ideal 'Bach temperament'.
In this study, we approach the search for a suitable temperament in a data-driven fashion. Instead of evaluating a temperament based on its theoretical characteristics, we explore the eMect that it has when playing the notes of the 48 compositions.

From the scala database of temperaments, we take all c. 1500 temperaments that contain 12 pitches per octave, and that have pure octaves (ratio 2/1). For each of these, we compute the deviation of each note from the just intonation of its interval with the lowest sounding note. This indicates the extent to which the sonority is 'out of tune'. We visualize the sequence of deviations as a heatmap. For example, the first four compositions from the first book (C Major, C Minor, Cis Major, and Cis Minor) result in the following heatmaps for Pietro Aaron's 1/4 comma meantone temperament:



To rank the temperaments, we compute for each 'time slice' the maximum deviation from just intervals and take either the maximum or the average over all time slices in the composition. Next, we compute the average over all 48 compositions.

The resulting ranked lists show which temperaments are suitable for performing the *Wohltemperirte Clavier*. Among the best are well-known historical temperaments by e.g., Artusi, Neidhardt and Marpurg, but also scales that were defined for the Indian Tamil tradition.

Ashley Burgoyne. ***A Corpus Analysis of Music Corpus Analysis: Topics in the Oxford Handbook***

There are 26 chapters of *The Oxford Handbook of Music and Corpus Studies* available online now. These chapters span many topics and approaches, which the editors have organised into seven loose categories: histories, guides, domains, corpora, music theories, case studies, and methodologies. It seems fitting, however, to consider other organisational patterns that may emerge from conducting a corpus analysis of these texts on corpus analysis. This poster will illustrate three other approaches to organising the chapters: one based on clustering term frequency–inverse document frequency (TF-IDF) weights, one based on latent Dirichlet allocation (LDA, a.k.a. topic analysis), and one based on point-wise mutual information. The results of these analyses overlap partially but not completely with the editors' classification scheme and highlight important trends in current thinking about musical corpora.

Poster session (part 2) 16:15-17:00

Iris van der Wulp. ***Investigating individual differences in linguistic statistical learning and their relation to rhythmic and cognitive abilities***

Music and language share rhythmic properties as well as cognitive underpinnings for processing these auditory stimuli through the entrainment of neural oscillations to the rhythm of the external stimulus. We investigate whether individual differences in neural entrainment as a measure of statistical language learning can be explained in part by musical, particularly rhythmic, abilities of an individual.

Statistical Learning (SL) plays a crucial role in speech segmentation, which is imperative for language acquisition and attainment. SL involves analyzing the likelihood (transitional probabilities) that one syllable follows another, with lower probabilities typically indicating boundaries between distinct words.

This study, detailed in our Registered Report (https://osf.io/2y6sx), explores the underpinnings of individual differences in auditory SL for word segmentation under the hypothesis that superior musical, particularly rhythmic, abilities may enhance SL abilities also for language. Data collection is ongoing, and we aim to present some initial results at the conference.

Adult participants are exposed to an artificial language of trisyllabic nonsense words, with SL assessed online via EEG measures of neural entrainment. They are also tested on their general musical (Goldsmith's Musical Sophistication Index) and rhythmic ability through music processing (Beat Alignment Test; Profile Of Music Perception Skills) and rhythmic speech production (Spontaneous Synchronization of Speech task). We also investigate participants' working memory (forward Digit Span) and vocabulary (Peabody Picture Vocabulary Task).

Bas Cornelissen, Tim Braithwaite. ***Delasol: automatic hexachordal solmization***

From the 12th century onwards, musicians were long trained to navigate a hexachordal pitch space using their hand—using Guidonian solmization. Although the practical importance of the hexachordal system has been debated (e.g. Mengozzi 2013, Urquhart 2021), it played an important role in pedagogy and features prominently in the work of some composers (e.g. Long 2023). This suggests that solmization might provide fruitful perspectives, but no computational studies of solmization have been published. The *Delasol* project aims to fill that gap by developing methods for automatic hexachordal solmization.

We take 16th-century solmization as the point of departure, partly because of the availability of reference solmizations. From 1560 on, a series of psalters were published in which the musical notes were accompanied by solmization syllables. The Geneven and Dutch psalters reflect the continental solmization style, while the English Whole Book of Psalms is more representative of the English solmization style, which simplified the mutations between hexachords. We have collected a small corpus of solmizations from these sources, which we use to evaluate our automatic solmization method.

The method we propose revolves around what we call a *gamut graph:* a graph representing the possible movements through the gamut, as made up of multiple hexachords. Weighting the steps through the graph, allows one to for example avoid mutation by making it more costly. We then model solmization as the cheapest walk through the gamut graph, and we can describe different solmization styles by varying the weights of the gamut graph. Our method produces very reliably reproduces the solmizations found in the psalters, with typical accuracies exceeding 95%, especially for the continental style. We hope this provides a stepping stone for future computational studies of solmization—or practical applications in the form of pedagogical solmization tools.

Çınar Gedizlioğlu, Kutluhan Erol. ***Enhancing Chord Generation in Modulating Musical Pieces: Integrating Local Key Detection with Deep Learning Models***

There has been numerous research on chord generation, examining various methods and approaches to create harmonic progressions. However, the focus of the majority of this research has predominantly been on musical pieces that are written in a single key. This narrow focus has led to the neglect of important musical concepts such as modulation, which involves changing from one key to another within a piece of music. In this work, we propose a chord generation algorithm specifically designed to handle pieces that contain modulations. The generation is done in conjunction with a local key detection algorithm (Gedizlioğlu & Erol, 2024). Since a dataset containing both modulations and chord annotations is required, we adopt the dataset used by Gedizlioglu & Erol (2024), extend it with chord annotations, and remove some of the pieces that contained no modulations. The local key detection algorithm identifies key regions as contiguous sets of measures through a regularization process. Our approach involves partitioning the piece based on this local key content and transposing every key region to a predetermined base key (C major or A minor). We then generate chords for the entire piece using an LSTM variant proposed by Lim et al. (2017), trained on pieces exclusively in C major or A minor. We finally transpose each key region back to their intended keys. We conclude the work by analyzing and discussing the results, suggesting further improvements. Potential future enhancements include musically meaningful alterations around modulation points using music theory and employing deep learning methods trained on datasets that incorporate local key content. Preservation (or lack thereof) of long-term dependencies, in the presence of modulating key regions, is another important point of discussion. This work provides insights on a mostly unexplored area within the field of MIR, motivating further research on the subject. The dataset provided alongside the work motivates further research to be as scientifically robust as possible, through a unified point of comparison.

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Lucas Hofmann, Craig S. Sapp, Fabian C. Moss. ***Metrical Irregularities and Polymetric Structures in Hugo Distler's Vocal Works: Towards a Digital Corpus Study***

Hugo Distler's (1908-1942) vocal compositions are distinguished by their intricate metrical structures, which pose significant challenges for both encoding and computational analysis.

While in his early works, Distler mostly adhered to conventional metrical notation, characterized by standardized bar lines, his later compositions demonstrate a progressive departure from these norms, utilizing a variety of notational innovations. These include frequent metre alternations within individual voices, beamed notes across bar lines, and even the substitution of bar lines with *Mensurstriche* (mensural bar lines), caesuras, or breath marks.

This presentation investigates the 52 motets from Distler's early collection, *Der Jahrkreis* op. 5 (1933), that we have encoded using Humdrum's kern format. Serving as a "precursor to his later, masterful vocal polyphony" (H. Grabner), the distinctive metrical features that define Distler's style are already apparent here. While most motets in this collection remain predominantly homophonic, yet with changes in metre, Distler already tries his hand at genuine polymetric constructions.

A particular focus is thereby given to the first motet, "O Heiland, reiß die Himmel auf," where each voice employs its own metres, reminiscent of Renaissance motets. Our metrical analyses involve identifying the metrical weightings within individual voices and comparing them with the composite metre of all voices.

Following on from this, future analyses will additionally examine the correlation between Distler's musical metres and the lyrics emphasis, reflecting his practice of aligning metre with textual diction.

The presentation will conclude with the prospect of a Bayesian model for polymetric analysis. This model aims to enhance our understanding of Distler's metrical stylistics, offering new insights into the complexities of his vocal polyphony, the stylistic changes over the course of his career as well as the compositional influences of his contemporaries.

Reinier de Valk. ***AbsoLutely Tabulous — A toolbox for computational processing and analysis of music in lute tablature***

Over the past decades, a plethora of MIR tools for performing diverse music-analytical tasks on symbolic music corpora have been established. The vast majority of these focus on music in common Western music notation (CWMN), including earlier, mensural forms of notation. Computational analysis of lute music, however, seriously lags behind. This is because of its notational format, lute tablature, which is notoriously sparse in information. Tablature is a prescriptive form of notation, providing the actions a player must take to produce the music, and not the musical structure itself, as descriptive forms of music (e.g., CWMN) do. It is a format that does not lend itself well to in-depth computational analysis — at least not without (often interpretative) preprocessing.

Nevertheless, over the past years, a handful of systems for computational analysis of lute tablature have been developed — whose objectives range from straightforward tasks (e.g., format conversion) through more challenging tasks (e.g., statistical analysis) to complex tasks (e.g., cross-corpus retrieval; automatic transcription).

In this paper, AbsoLutely Tabulous (AbTab), a toolbox for computational processing and analysis of music in lute tablature, is presented. It is developed in the context of the E-LAUTE (Electronic Linked Annotated Unified Tablature Edition) project, a Weave (FWF/DFG/SNSF)-funded international and interdisciplinary research project aiming to study the lute in the German-speaking area. AbTab is intended to be used by researchers, performers, and others interested alike, and combines symbolic music notation-general and lute tablature-specific tools within a single environment. This allows users to create workflows that integrate a series of previously unconnected tools to suit their own specific needs.

AbTab is modular by design: tools (modules) can be added and removed without this affecting its general functionality. The version presented is a functional prototype, containing a basic set of tools for tasks such as format conversion, transcription into CWMN, cross-corpus comparison, and analysis/visualisation. It will continuously be extended with new tools developed within E-LAUTE and elsewhere. AbTab is run from the command line, but will be integrated within the E-LAUTE web environment.

Nick Harley, Geraint Wiggins, Jamie Forth, David Lewis, Tim Crawford. ***A Common Hierarchical Abstract Representation for Music: applications in historical musicology***

Given a more-or-less comprehensive corpus of encoded historical lute tablatures like the augmented ‘Electronic Corpus of Lute Music’ (ECOLM) currently under development, an entirely new mode of investigation of the corpus and its relation to other repertories, such as contemporary vocal or keyboard music, could become possible. Text-based encodings of works may be directly compared using exact matching, but this does not allow recognition of transposed versions, or those for a differently-tuned instrument than a query; furthermore, duple- and triple-time versions of the same music will not, in general, be matched, nor those in which durations have been globally augmented or diminished. While ingenious indexing strategies might overcome some of these problems for a particular repertory of music (for example, the 16th-century lute fantasy and related genres), they are unlikely to permit extra-corpus searches for

parallel motives or passages within contemporary vocal music, which are being increasingly recognised as crucial in the evolution of western lute music.

We present CHAKRA/CHARM, an abstract, hierarchical music knowledge representation system that admits federation of data sources in multiple formats by means of semantic-level annotation and query specification. From the user's perspective, search and discovery operations are specified in terms of musical terminology applied to "constituents" (groups of musical objects – e.g., notes, phrases, motives, etc.), independently of the data source and format. CHAKRA/CHARM is already equipped with data interfaces for MIDI and TabCode (other formats in progress), and it can represent audio recordings, allowing detailed association of individual notes with specific spectral content, permitting the annotation of richly detailed analyses of sources and their direct, detailed connection with performance recordings. In the current presentation, we show how the TabCode ECOLM corpus may be compared with a wider range of music in MIDI format, to find key motives, borrowed from elsewhere.

Johanna Devaney, Alexander Morgan, Daniel McKemie. *pyAMPACT: A Score-Audio Alignment Toolkit For Performance Data Estimation And Multi-Modal Processing*

pyAMPACT links symbolic and audio music representations to facilitate score-informed estimation of performance data in audio, as well as general linking of symbolic and audio music representations. pyAMPACT builds on the original MATLAB-based AMPACT's algorithms (Devaney et. al. 2009, 2011, 2017, and 2019) and offers greater extensibility through its integration with librosa (McFee et al. 2015) and music21 (Cuthbert and Ariza 2010). pyAMPACT can read a range of symbolic formats and can output note-linked audio descriptors/performance data into MEI and Humdrum kern files. The audio analysis uses score alignment to calculate time-frequency regions of importance for each note in the symbolic representation from which to estimate a range of parameters. These include tuning-, dynamics-, and timbre-related performance descriptors, while timing-related information is available from the score alignment. Beyond performance data estimation, pyAMPACT also facilitates multi-modal investigations through its robust infrastructure for linking symbolic representations and annotations (such as harmonic analyses) to corresponding audio recordings.

In addition to describing the current state of the development of pyAMPACT, this talk will demonstrate the utility of pyAMPACT for polyphonic early music through a set of recordings of Praetorius' Es ist ein Ros entsprungen. This case study examines the relationship between melodic and harmonic patterns identified with CRIM (Freedman et al., 2022) to timing-, tuning-, dynamics-, and timbre-related performance data estimated with pyAMPACT. This talk will also discuss planned future directions for pyAMPACT, which includes exploring how pyAMPACT can be more directly integrated with other symbolic music data frameworks, such as DIMCAT (Hentschel et al. 2023) and musif (Llorens et al. 2023), both to leverage their analytic tools and more efficiently import and process the related corpora. We are developing tools to support the use of pyAMPACT with musical score substitutes, such as annotations from Tony (Mauch et al. 2015), to expand the types of repertoire that can be analyzed with pyAMPACT.

Laurent Pugin, Johannes Hentschel, Yannis Rammos, Andrew Hankinson, Martin Rohrmeier. *MEI-Basic support in MuseScore*

In the spring of 2023, the Digital and Cognitive Musicology Lab (DCML) at EPFL and the RISM Digital Center started to work on implementing MEI support in MuseScore, a widely used open-source music notation editor. MuseScore's UI and feature set made it an ideal candidate for MEI integration. The aim was to enable both export and import capabilities, facilitating diverse use cases from digital editions to computational music analysis corpora. The implementation of MEI support in MuseScore focused on MEI-Basic, a subset designed for notation interchange. Using the LibMEI parser, which has also been integrated into Verovio, ensured a robust implementation with long-term maintenance capabilities. The emphasis was on achieving round-trip lossless conversion, maintaining consistency between exported and re-imported MEI files.

MuseScore 4.2, the first version featuring MEI-Basic support, was released in December 2023, which marks a significant achievement for the MEI community. The features supported include time signatures, key signatures, notes, dynamics, lyrics, and more. Despite this achievement, limitations exist, such as metadata export and ID handling, which will require future improvements. Moving forward, feedback and community involvement will be important for refining MuseScore's MEI support and establishing best practices. Users engaging with MuseScore for their projects will provide valuable insights, enabling iterative improvements and recommended workflows to be established.

Drinks 17:00-18:00

Friday 18 October, Botanic Gardens, Wachendorff room

Budapestlaan 17 3584 CD Utrecht

Room opens 10:00

Early music computing (2) 10:15-11:35

Chair: Peter van Kranenburg

Marnix van Berchum. *"What has Kevin Bacon ever done for musicology?": network science, early music, and The Oracle of Josquin*

In the late nineties two University of Virginia students built the *Oracle of Bacon* website (www.oracleofbacon.org). Based on the more serious 'Erdös Numbers' the site calculates the distance of film actors to actor Kevin Bacon. The connection between two actors is the film in which they co-act and the distance is expressed in the 'Bacon Number'. Although the career of Kevin Bacon is impressive, and many of his films are worth watching, the network of Hollywood actors has never been one of my main interests. It made me wonder though if the underlying ideas could be applied to the transmission of music in the sixteenth century. What if we exchange actors for *composers* and films for *musical sources* in which the attributions to the composers occur? Can we, for example, calculate a 'Josquin Number'? And, what would we learn from this? How will our understanding of the musical culture from the sixteenth century change if we express the relations between sources, composers and compositions in metrics from network science? Is a network representation fruitful for studying music from a distant past?

This contribution will introduce my PhD research, in which I study the repertory of sixteenth-century polyphonic settings of the *Te deum laudamus* through different network lenses, making use of methods and tools from network science. In order to use these methods and tools information found in musicological literature is transformed into data elements. Although a microscopic network view might resemble the close reading methods so common in historical musicology; the macroscopic view provides, with a more quantitative approach, new insights in (the data on) sixteenth-century music, its sources and composers. It might even tell us who was the centre of the musical universe in that century...

Anna Plaksin. *Towards an evidence-based theory of scribal micromutations in the transmission of renaissance music*

During a substantial era in European music history, written notation served as a medium for recording music and musical practices. A written musical source not only bears witness to a piece of music but also encapsulates practices of transforming aural phenomena into graphical representations and vice versa. Unlike oral transmission, which relies on proximity, written records of music could traverse vast distances. Among other things, this allowed Renaissance polyphony to be practised throughout the European continent and beyond. And as the research of Allan Atlas and Cristina Urchueguía shows, its dissemination can be

studied through variant readings of its sources. However, this research is not only laborious but also methodologically challenging as it is traditionally conducted using stemmatics. But while a wider use in the analysis of music transmission would rely on comparable results, stemmatic trees often lack comparability between editors.

Methods like sequence alignment and phylogenetic analysis are widely used in computational life sciences and have already proven to be promising in the humanities. While sequence alignment is already used successfully in the music domain for similarity searches, the application of phylogenetic methods for studying music transmission still lacks adequate evolutionary models. In contrast to similarity models, these need to be based on single dot mutations from one generation to the following. Developing such a model for Early Music is hard. Not only is there too little data available, but unknown losses also distort empirical evidence. Moreover, since historical data is per se finite, any use of real data in model development prevents its later analysis with the very same model.

In this presentation, I will share my previous approaches to developing substitution models and explore the potential of integrating behavioural experiments into model development for Early Music computing.

Tim Crawford, David Lewis. ***Towards a comprehensive, unified, interoperable and searchable corpus of lute music***

Developments in the quarter-century since the Electronic Corpus of Lute Music (ECOLM) was instigated at KCL make it possible to imagine the complete surviving repertory for the western European lute becoming available in machine-readable encodings. The significance of this cannot be over-emphasised: the lute was unquestionably the most important instrument of the renaissance and early baroque periods, and remained prominent in parts of Europe until after 1750.

When written down or printed, music for the lute and related instruments always used tablature, a notation form that carries different information to staff notation, such as where the player should place their fingers on the fingerboard of the instrument. There is a strong need for a corpus of diplomatic encodings of the tablature sources, with staff-notation transcription a secondary, if important, step.

Scholarly editions were the original intention of ECOLM, yet make great demands on expertise and time, nor was ECOLM solely about music editing, and six years of funding resulted in fewer than 2,000 encoded pieces. In the interim, others have also been creating tablature editions, often using specialist engraving software, and often intended for an audience of amateur players. These include 8,500 files generated by John Robinson, mainly as printed playing editions for the UK Lute Society, and more than 20,000 files curated and/or encoded by Sarge Gerbode. A further 1,500 files of the complete output of the Louvain music publisher Pierre Phalèse, have been encoded by Jan Burgers in a scholarly tablature edition.

To unite these resources – to create an augmented ECOLM – we need transparent approaches to managing data provenance, editorial practice, catalogue data and file formats. An important first step is simply identifying the pieces encoded in a machine readable way. To do this, we will connect them with the comprehensive source-inventories (974 sources, with over 60,000 tablature incipits) listed on the web-site mss.slweiss.de compiled by the late Markus Lutz and Peter Steur. This requires a combination of automated content-based retrieval and manual effort, along with iterative data cleansing.

This paper reports our progress on the way to an augmented ECOLM and considers the potential it offers for the wider investigation of lute music in its historical context.

Mirjam Visscher, Frans Wiering. ***Milking the modes: audio analysis of renaissance polyphony***
In *Measuring Musics* (2024), Bas Cornelissen classifies gregorian chant from the Cantus database into modes using pitch profiles with good results (F1-scores between .88 and .90). This method is based on monophonic encoded music. Is it possible to use this approach to predict the mode of recordings of modal polyphony?

Modal cycles are an excellent genre to answer this question. A modal cycle is a collection of compositions, ordered by an accepted sequence of the modes, compiled by the composer or by someone else, such as an editor or printer. In this talk we explore a set more than 1000 recordings of about 80 modal cycles collected in Wiering, *Language of the Modes* (2001). We will use this collection to investigate whether pitch (class) profiles extracted from recorded polyphony can be employed to detect the mode of a composition. We will especially zoom in on the difference between pitch profiles and pitch class profile on the one hand and between mode and mode family on the other.

Coffee break 11:35-12:00

Computational music analysis 12:00-13:00

Chair: Anja Volk

David Meredith. ***A parallel algorithm for finding maximal transformed matches of polyphonic patterns in unvoiced polyphonic music***

We present a parallel algorithm for finding transformed matches of a query pattern in a database of symbolic music encodings in which voice information is absent, ambiguous or unreliable (e.g., an encoding of a score or performance of a keyboard work). Our algorithm allows users to define the class of transformations by which matches may be related to a query pattern. We assume an encoding, D, in the database and the query pattern, P, are represented by sets of k-dimensional points, $D, P \subset \mathbb{R}^k$. In addition to P and D, the algorithm takes as input a user-defined class, F, of transformations, each of which must be a bijection over $\mathbb{R}^k$.

We define Q to be a *maximal match* of P in D with respect to F, if there is an $f \in F$ such that $Q = f(P')$, where $P' \subseteq P$ and there is no S such that $P' \subset S$ and $f(S) \subseteq D$. Our algorithm computes all maximal matches of P in D with respect to F. If $m = |P|$ and $n = |D|$, then the algorithm does $\Theta((mn)^\beta \log n)$ work, has $\Theta(\beta(\log m + \log n))$ span and uses $\Theta((mn)^\beta)$ space, where β is the *basis size* associated with the transformation class F. For example, if F contains the traditional contrapuntal transformations of transposition, augmentation, diminution, inversion, retrograde and their combinations, then $\beta = 2$. We evaluated the algorithm on two musicological tasks: discovering occurrences of the "HAYDN" theme in Ravel's *Menuet sur le nom d'Haydn*, on which the algorithm achieved an F_1 score of 0.70; and discovering subject entries in *Contrapunctus VI* from Bach's *Die Kunst der Fuge*, on which the algorithm achieved an F_1 score of 0.93.

Christina Anagnostopoulou. ***A measure of music complexity for the analysis of improvisation***
Music complexity can be broadly defined as the factor of intricacy, variety or sophistication there is within a piece or segment of music. There have been various approaches to complexity in the literature, some focusing on the neutral (musical) level and some on the aesthesic or perceived level. Radocy (1982) refers to how elaborate or complicated the music can be, including factors such as rhythms, melodies,

instrumentation, and, perhaps surprisignly, lack of formal structure. Streich (2007) defines music complexity in auditory musical signals and includes aspects of acoustics, rhythm, timbre, and tonality. Eerola (2016) assesses two types of models for melodic complexity: one based on expectancy violations and the other related to an information-theoretic account of redundancy in music. Sauve and Pearce (2019) on the other hand look specifically at complexity as perceived by a listener. Finally, more recently, De Berardinis et al (2022) focus on measuring structural complexity for the evaluation of music generation models.

In this paper we define a notion and measure of complexity for music analysis purposes, and especially for analysing improvisations, by studying separately the various musical parameters of a piece of music. A robust knowledge representation formalism is used to separate the various musical parameters, the Multiple Viewpoint formalism (Conklin and Witten, 1995; Conklin and Anagnostopoulou, 2006). This formalism not only offers a rich detailed representation, but also a way to capture change within each musical parameter.

In our proposed measure of complexity we use a set of viewpoints to describe the musical surface, which record ratios of parameter values, amount of change observed, segmental values, global features and descriptions of structure. Each viewpoint gets a complexity score. At the end, all scores from each viewpoint are taken into account, in order to classify a piece or a segment into one of five predefined categories (A, B, C, D, or E) which describe the overall musical complexity. As an example, three monophonic improvisations of different complexities are analysed.
This way of analysing the musical surface can prove useful in a number of tasks, such as the analysis of human or machine improvisations, any generation task, educational and therapy applications, and others. The method also allows for different aspects to be studied separately, for example rhythmic, structural complexity and so on. The extension to polyphony or other textures is discussed, as well as the creation of a computational model to automate the process.

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Frans Wiering. ***My career: a midterm review***

In looking back at your career you might be tempted go back to first beginnings, or to focus on a perceived chain of highlights. Instead I'll identify four milestones (the precise nature of which will be disclosed in my talk) that gave an unexpected twist to my career. Hopefully analysing their impact will retroactively bring some order in what I often perceive as a rather messy path, and help me in finding a new focus after passing the present fifth milestone of official retirement.

Closing 13:00-13:15